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**Patentanmeldung Nr. | Patent application No. | Demande de brevet n°**

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Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
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(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
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Gesture-based input device for a user interface of a computer

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# Gesture-based input device for a user interface of a computer

## Technical Application Area

The present invention relates to a gesture-based input device for a user interface of a computer and a new interface technology enabling gesture-based navigation and interaction, searching, browsing and selection of web pages and multimedia content graphical user interfaces (GUIs).

## State of the Art - Drawbacks of current technology

The most commonly used technologies for gesture-based interfaces include data gloves, computer vision techniques and magnetic or infrared sensors. Data gloves are expensive and also restrains users to a device; also, data gloves are not suitable for use in public spaces. Computer vision systems are sensitive to lighting conditions and have a comparably low update rate, though they can be quite accurate. But vision systems often force the user to adapt a new means of interaction (e.g. head or eye movement). Infrared and magnetic sensors also require the user to wear a device. EFS-based navigation techniques require users to undergo tedious calibration procedures.

Moreover, gesture-based touchless input devices for user interfaces of computers are known using cameras for determining the position and gesture of e.g. a user's hand. Examples of these technologies are described in DE-A-42 01 943, DE-A-199 18 072, DE-A-100 07 891, DE-A-100 56 291, US-B-6 252 598, JP-A-09258945 and JP-A-10031551.

Moreover, from DE-A-43 12 672 a touchless cursor-control-like input device for computers is known which comprises proximity switches for controlling

cursor movement and other functions. Each proximity switch functions based on a capacitance measurement. These switches cannot detect the position of for example a user's finger within their sensitive area but can merely detect that within the sensitive area a user's finger is located.

**Solution provided by the New Development**

The invention provides a gesture-based input device for a user interface of a computer comprising

- two pairs of antennas wherein the antennas are arranged for surrounding a two-dimensional sensor field corresponding to the user interface and providing different options or tasks to be selected by a user,
- a platform for supporting a user,
- a DC power supply connected to the platform and
- a circuitry connected to the antennas for determining, relative to each of the antennas, the position of that part of a user supported by the platform, e.g. a user's hand, being closest to the sensor field,
- wherein the position of the part of the user in each dimension of the sensor field is determined based on the relation of two voltage signals of the circuitry, respectively, each voltage signal indicating the distance between the part of the user and the respective antenna limiting the respective dimension of the sensor field,
- whereby the position within the sensor field closest to the part of the user is determined without any calibration of the sensor field to the user.

Individual embodiments of the invention are referred to in the dependent claims.

The system according to the invention is an alternative to the computer mouse or the touchscreen, because it allows the user to command and control the cursor via plain pointing gestures. The system can be used with all standard monitors and especially (large) wall projections. The interface according to the invention does not require users to wear or hold dedicated devices; in addition

it does not need to be calibrated for different users. It is thus easy to maintain and protect from damage. The system is thus aimed at information systems in public spaces, such as information kiosks or multimedia display windows, which constantly have to cope with these issues.

**Basic Features of the Solution**

Using an array of electrodes, the system according to the invention generates a weak electric field that reacts to the capacitance of the user. Body movement (e.g. by arm or hand) results in a change of the electric field, which in turn is measured and analysed by the system in order to measure the proximity to each of the electrodes; the exact position of the arm or hand can then be computed using standard approximation techniques. An algorithm allows it to use the system without prior calibration. Users can therefore control the cursor on the screen by simple pointing gestures. Objects can be selected by e.g. pointing at the same object for few seconds.

The technology is largely built on two areas: the hardware developed is based on highly sensitive electric field sensor (EFS) and an array of antennas. The software was designed and implemented to analyse the user interaction via the sensor array and estimate the arm position from it in order to enable browsing and selection. This includes an algorithm for adaptive relative reference which compensates for omitted calibration step.

**Improvements and Advantages over the State of the Art**

The system according to the invention is a non-contact interface that doesn't require the user to calibrate the system or wear a device. He can interact with the computer by pointing at the screen in a very natural and playful way. It provides good resolution and a high update rate (up to 1kHz) for browsing web pages and multimedia applications.

The invention will be described in more detail hereinbelow referringto the drawing in which

Fig. 1 shows an embodiment of the invention (referred to as Info-Jukebox),

Fig. 2 shows a principle of the sensor,

Fig. 3 shows a natural electromagnetic field around human body,

Fig. 4 shows an enhanced human body electromagnetic field,

Fig. 5 shows an electronic circuit model for the sensor, and

Fig. 6 shows an antenna frame for the sensor.

**Example**

The Info-Jukebox is a multimedia archive installation for public spaces (see Fig. 1). It presents collections of multimedia information on a multi-screen (on multiple screens) which can be accessed via a gesture-based interface. ECCO-sensors translate simple pointing gestures into screen coordinates in order to control the cursor. The selected information (e.g. videos) is presented on the navigation space as well as on a large projection to ensure that the Info-Jukebox can be installed in large public spaces.

**Technical Principle**

In order to ensure the basic functionality of the jukebox, two types of information are necessary: one is the current position of the cursor, and the other is selection of an item. Both parameters should be determined from the user's arm position. And indeed, one can do so by applying basic physics theory: It is well-known that capacitance C exists between two objects and C is proportional to

$$C \propto \frac{K}{d} \tag{1.1}$$

where d is the distance between the two objects and K is the factor of the object characteristic and environment effect.

The capacitance C is a basic parameter in electronic science. By obtaining the value C, the distance between the two objects can be determined. Moreover, if two objects A1 and A2 are placed at fixed positions (see Fig. 2) in a coordinate system, the position of the new object B can be determined by measuring the capacitance between the object pairs A1B and A2B.

This is the basic principle underlying in the sensor of the present invention. B corresponds to the arm of the user. A1 and A2. Once the distance is measured between A1 and B and A2 and B, one can infer the position of the object B. By means of suitable software routines, one can move the cursor on the screen in accordance with the movement of the arm.

It is widely known that the human body can radiate (or reflect) energy in the form of heat, infrared waves, electromagnetic power and others. Especially, the electromagnetic field is most closely related to the body, since it may be caused by the biochemical effects in the cells, friction of clothes, space electric field induction or coupled from power cable. This is why sometimes people may feel shocked by body electricity, especially when one takes off his/her wool sweater in dry winter day. Indeed, the human body is surrounded by an electromagnetic field more or less all the time, as can be seen in Fig. 3.

Given such field, body gestures can be captured by suitable sensors and then translated into computer commands. One of the most common gestures in life is finger or arm pointing gesture. This kind of gesture language has been widely adopted in human computer interfaces based, for example, on computer vision or others. Once it is possible to detect the change of the field cause by body movements, one can use it to control computers in some ways,

e.g. to navigate a screen cursor or to emulate isolated buttons on the keyboard.

Unfortunately, the natural electromagnetic field around the human body is extremely weak and difficult to deal with for human computer interaction, whereas artificially created fields are easier to control.

When the body is immersed in an electromagnetic field, it will become a medium or path for the field and extends to the surrounding environment as illustrated in Fig.4. In fact, the human body field or energy can be enhanced in this way to invisibly extend the measurable size of the body.

In the method, the enhanced field is measured by a voltage coupled solution accompanied by a custom-designed frame of four or more antennas.

The principle of the sensor may be expressed in the model of Fig. 5.

When the user is enhanced by the artificial field, the field around him can be regarded as a signal source represented in the model as Ui. When the user moves his arm close to the antenna(s), the path between user and sensor antenna can be described as the equivalent capacitance C in the model, via which the signal passes to the front processing circuit and then to the computer.

From Fig. 5, the output of the antenna $Uo$ can be obtained as follows:

$$|Uo| = \frac{R2}{\sqrt{R1^2 + \frac{1}{(2\pi fC)^2}}}|Ui| \qquad (0.1)$$

where $|Uo|$ and $|Ui|$ are the amplitude of the signal,

$R1$ and $R2$ are the resistors used, and

$f$ is the frequency of the signal

Since $f$ is in the range kHz and $C$ is in pF unit, $R1 << \frac{1}{(2\pi f C)^2}$. It follows that,

$$|Uo| \approx 2\pi f C R2 |Ui| \qquad (0.2)$$

So the measured amplitude of $Uo$ contains the distance information of arm and antenna.

For different users however, the electrical property is different. It is impossible to couple the same voltage strength $Ui$ to everyone without careful calibration. In order to overcome this shortcoming, an array of antennas as demonstrated in Fig. 6 is used.

The prototype antenna frame is made from a 50 x 50 cm metal cannulation accounting to four antennas. Compared to the size of the hand, it can be regarded as the line and point problem for capacitance which, resulting in homogeneous reception characteristics for the antenna frame.

The prototype frame consists of four antennas and each has a processing circuit as discussed above (cf. Fig. 5). If the signal from antenna **a** is named as $|Uo|_a$ and the signal from the antenna **c** as $|Uo|_c$ one can infer

$$H = \frac{|Uo|_a}{|Uo|_c} = \frac{C_a}{C_c} \qquad (0.3)$$

$C_a$ and $C_c$ are equivalent capacitance between the arm and the antennas **a** and **c**, respectively.

Since capacitance is proportional to

$$C \propto \frac{K}{d} \qquad (0.4)$$

where $d$ is the distance between the two objects and $K$ is the factor of the object characteristic constant and environment effect. Thus:

$$H \approx \frac{d_c}{d_a}$$

$d_a$ is the distance between the user's hand and antenna **a**, and likewise for $d_c$ to antenna **c**. From this equation, it can be seen that the value of H includes the relative distance information between the user's hand and the antenna. Furthermore, one can cancel out the uncontrollable effects to the environment interference.

If the last value of $H$ is stored as $H_L$ and the current one as $H_c$, the difference is

$$\Delta H = H_c - H_L \qquad (0.5)$$

One now can compute $\Delta H$, and use this parameter to control the relative movement of the cursor. Thus, the position change is used to move the cursor and not the position itself which makes it work analogous to a mouse.

For the selection control of the JukeBox, simple Boolean logic is used. It is assumed that the user makes a selection when he drops down his arm. When the arm is raised, the signal strength of all four signals will increase, with the opposite effect when the arm is dropped.

## CLAIMS

1. Gesture-based input device for a user interface of a computer comprising
   - two pairs of antennas wherein the antennas are arranged for surrounding a two-dimensional sensor field corresponding to the user interface and providing different options or tasks to be selected by a user,
   - a platform for supporting a user,
   - a DC power supply connected to the platform and
   - a circuitry connected to the antennas for determining, relative to each of the antennas, the position of that part of a user supported by the platform, e.g. a user's hand, being closest to the sensor field,
   - wherein the position of the part of the user in each dimension of the sensor field is determined based on the relation of two voltage signals of the circuitry, respectively, each voltage signal indicating the distance between the part of the user and the respective antenna limiting the respective dimension of the sensor field,
   - whereby the position within the sensor field closest to the part of the user is determined without any calibration of the sensor field to the user.

2. Gesture-based input device according to claim 1, wherein movement of the part of the user within a plane parallel to the sensor field is determined based on the difference between a former position of the part of the user determined and the actual position of the part of the user determined.

3. Gesture-based input device according to claim 2, wherein, when the determined position of the part of the user is left substantially unchanged for a predetermined period of time, this is interpreted as selecting an option or task offered to the user through the user interface represented by the sensor field.

4. Gesture-based input device according to any one of claims 1 to 3, wherein the senosr field comprises a screen and a cursor moved and positioned according to the movement and position of the part of the user.

## Abstract

## Gesture-based input device for a user interface of a computer

The gesture-based input device for a user interface of a computer comprises two pairs of antennas wherein the antennas are arranged for surrounding a two-dimensional sensor field corresponding to the user interface and providing different options or tasks to be selected by a user, a platform for supporting a user, a DC power supply connected to the platform and a circuitry connected to the antennas for determining, relative to each of the antennas, the position of that part of a user supported by the platform, e.g. a user's hand, being closest to the sensor field. The position of the part of the user in each dimension of the sensor field is determined based on the relation of two voltage signals of the circuitry, respectively, each voltage signal indicating the distance between the part of the user and the respective antenna limiting the respective dimension of the sensor field, whereby the position within the sensor field closest to the part of the user is determined without any calibration of the sensor field to the user.

(Fig. 6)

Fig. 1

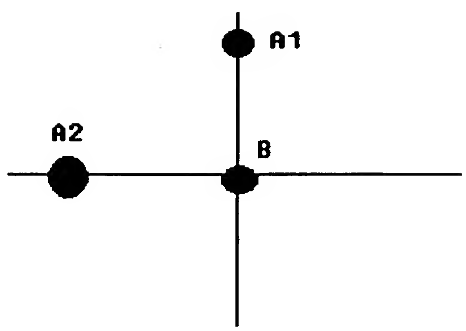


Fig. 2

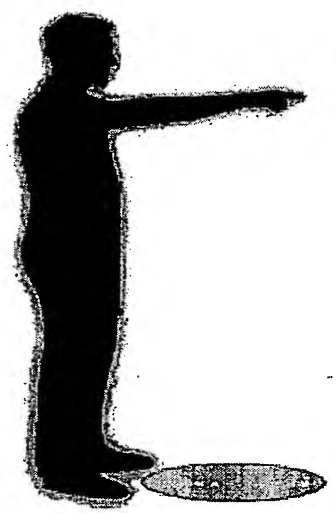

Fig. 3

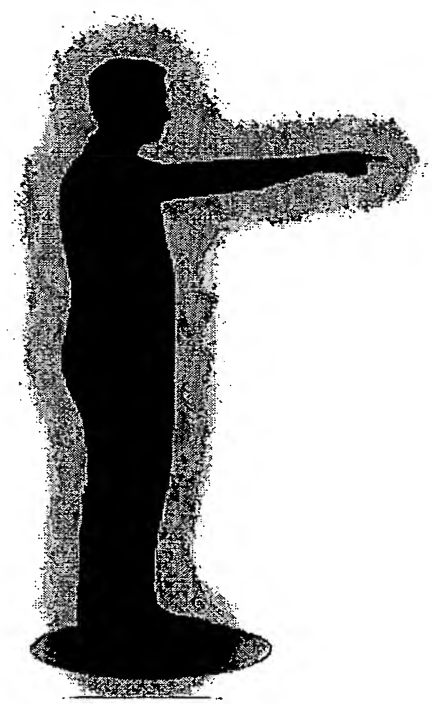

Fig. 4

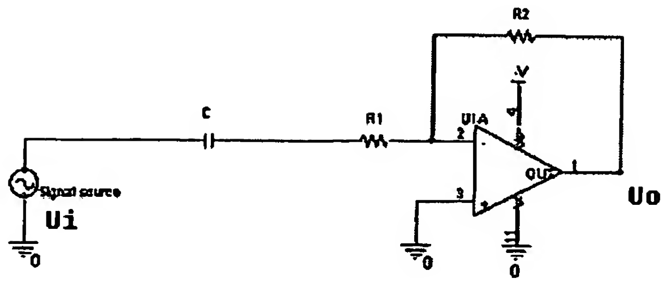


Fig. 5

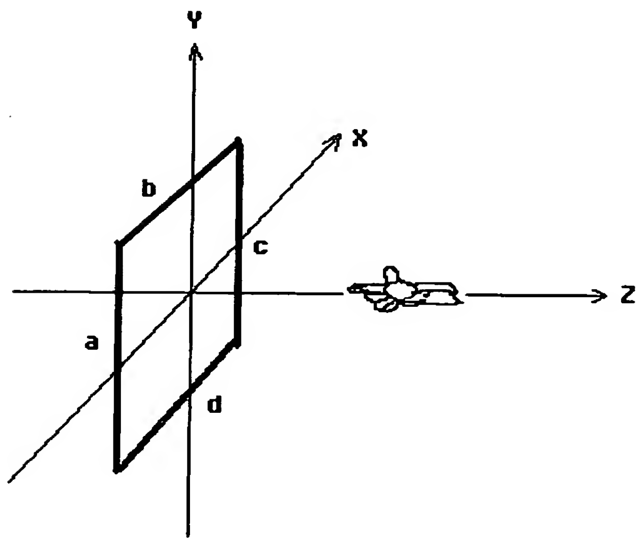


Fig. 6